Conf-750607--8

TRANSPORT/DIFFUSION COMPARISON FOR THE FFTF ENGINEERING MOCK-UP CRITICAL

G. F. Flanagan (ORNL) and D. L. Selby (UCCND-CSD)

In the current designs of fast reactors, the control monitoring during subcritical and low power operation will be based on data from ex-core detectors. These detectors are located in the radial shield of the Fast Flux Test Facility (FFTF) at approximately 113 cm from the core center. Fluxes in the area of the detectors are anisotropic and, therefore, the detector reaction rates could prove expensive to calculate.

A large scale reactivity measurement experiment with the FFTF engineering mock-up critical core loaded into the ZPR-9 facility at Argonne National Laboratory was conducted in order to determine the adequacy of the low-level flux monitoring (LLFM) system in predicting the reactivity.

Numerous transport calculations have been performed at ORNL in support of the analysis of this experiment and have been reported previously.[1]

A major concern in interpreting the results of this experiment is the usefulness of diffusion theory in predicting the LLFM reactivities. Diffusion calculations were performed for several of the experimental configurations.

The cross-section set used was identical to that used in the transport calculations reported in Reference (1) except that the usual transport corrected diffusion approximation was applied in which σ_{tr} was obtained as shown below:

$$\sigma_{tr}(E) = \sigma_T(E) - \bar{\mu}_{os}(E)\, \sigma_s(E) \tag{1}$$

---

†Research performed at Holifield National Laboratory operated by Union Carbide Corporation for the Energy Research and Development Administration.

A comparison of the transport and diffusion results from both one-dimensional (cylindrical) and two-dimensional (X-Y) calculations are shown in Figs. 1 and 2, respectively.

Curve A in both figures is a S_4P_3 transport calculation using zone-dependent and energy-dependent buckling to represent the leakage in the Z direction. The bucklings were obtained from three-dimensional KENO Monte Carlo calculations.[2] The S_4P_3 distributions are in excellent agreement with experimentally measured detector and foil distributions and are considered "exact" for this comparison. Curve B in each figure indicates the same calculation using diffusion theory. When compared to the S_4P_3 results (Curve A), the error is less than 3.5% over the core region in one dimension and somewhat larger on the order of 10%-15% in parts of the core, for the two-dimensional calculation due to the explicit representation of control rods. However, the error reaches a maximum of 132% in one dimension and 184% in two dimensions near the middle of the reflector region. The transport and diffusion results again tend towards agreement as one proceeds into the shield. Curve C in Fig. 1 represents a one-dimensional diffusion calculation in which the Z direction buckling is represented by a single value over all zones. The agreement with the S_4P_3 results is as reported in a previous transport approximation comparison.[3]

These results indicate that the careful analysis of ex-core detection systems is necessary. The methods used to represent the buckling are most important in judging the effectiveness of diffusion techniques. Similar comparisons will be reported on the effect of diffusion and buckling on the blanket breeding ratio in an LMFBR critical mock-up.

REFERENCES

1. G. F. Flanagan, D. B. Simpson, D. L. Selby, and J. T. Mihalczo, "Transport Calculation for Reactivity Measurement in Subcritical Configurations of the FFTF Engineering Mock-up Core," TRANSACTIONS OF THE AMERICAN NUCLEAR SOCIETY ANNUAL MEETING held in Philadelphia, Pennsylvania, 18: 268, June, 1974.

2. L. M. Petrie and N. F. Cross, "Energy and Region-Dependent Bucklings for the FFTF Engineering Mock-up Core from Monte Carlo," TRANSACTIONS OF THE AMERICAN NUCLEAR SOCIETY ANNUAL MEETING held at Philadelphia, Pennsylvania, 18: 348, June, 1974.

3. G. F. Flanagan, N. M. Greene, W. W. Engle, Jr., and E. T. Tomlinson, "Comparison of Transport Approximations for Reactor Physics Calculations in a Fast Reactor," TRANSACTIONS OF THE AMERICAN NUCLEAR SOCIETY WINTER MEETING held in San Francisco, California, 17: 486, November, 1973.

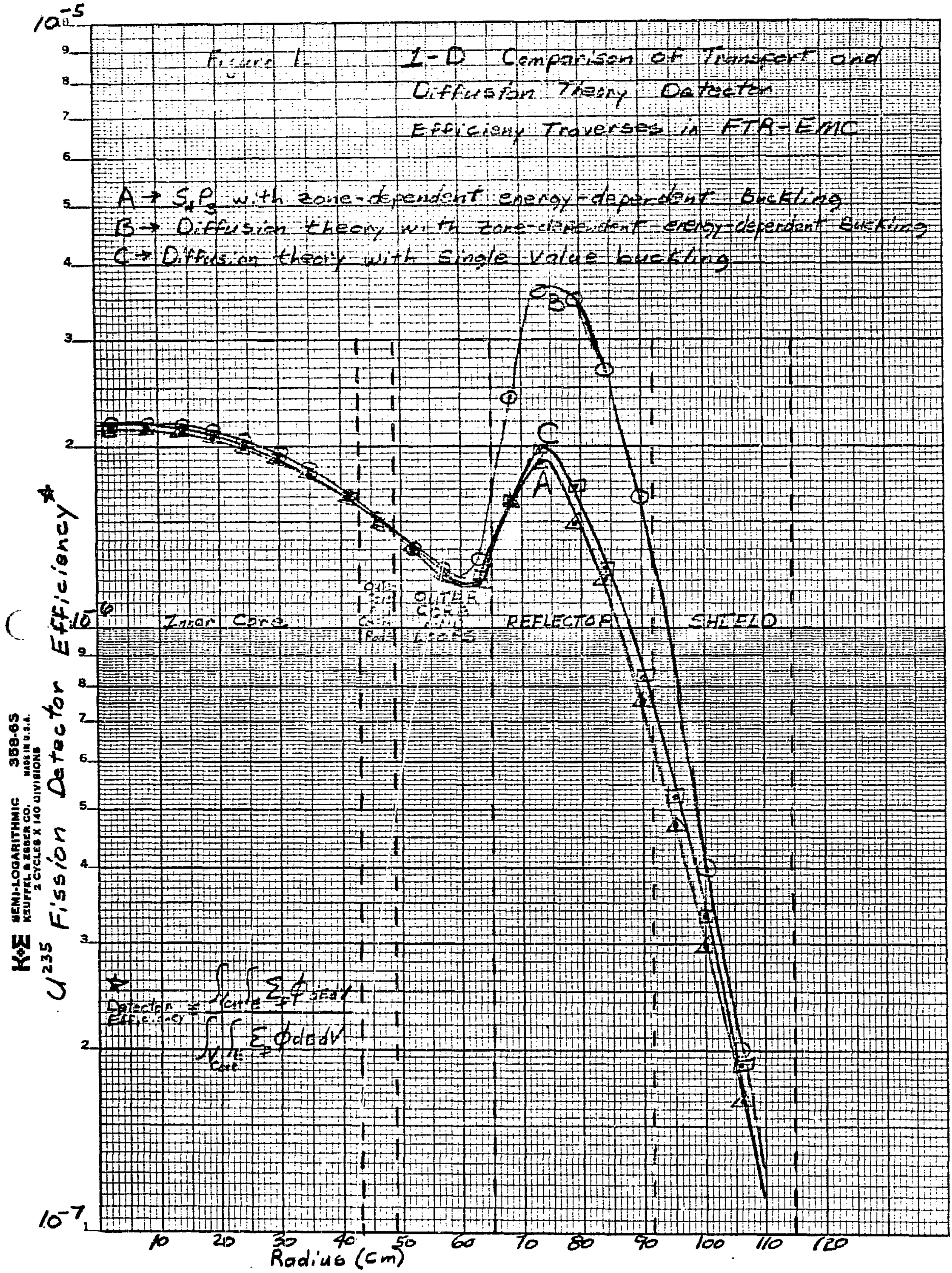
Figure 1. 1-D Comparison of Transport and Diffusion Theory Detector Efficiency Traverses in FTR-EMC
A → S_4P_3 with zone-dependent energy-dependent Buckling
B → Diffusion theory with zone-dependent energy-dependent Buckling
C → Diffusion theory with Single Value buckling
Inner Core
OUTER CORE
REFLECTOR
SHIELD
U^{235} Fission Detector Efficiency*
Radius (cm)
* Detector Efficiency = $\frac{\int_{cell}\int_E \Sigma_f \phi \, dE\, dV}{\int_{V_{core}}\int_E \Sigma_f \phi \, dE\, dV}$
K+E SEMI-LOGARITHMIC 358-65 KEUFFEL & ESSER CO. MADE IN U.S.A. 2 CYCLES X 140 DIVISIONS

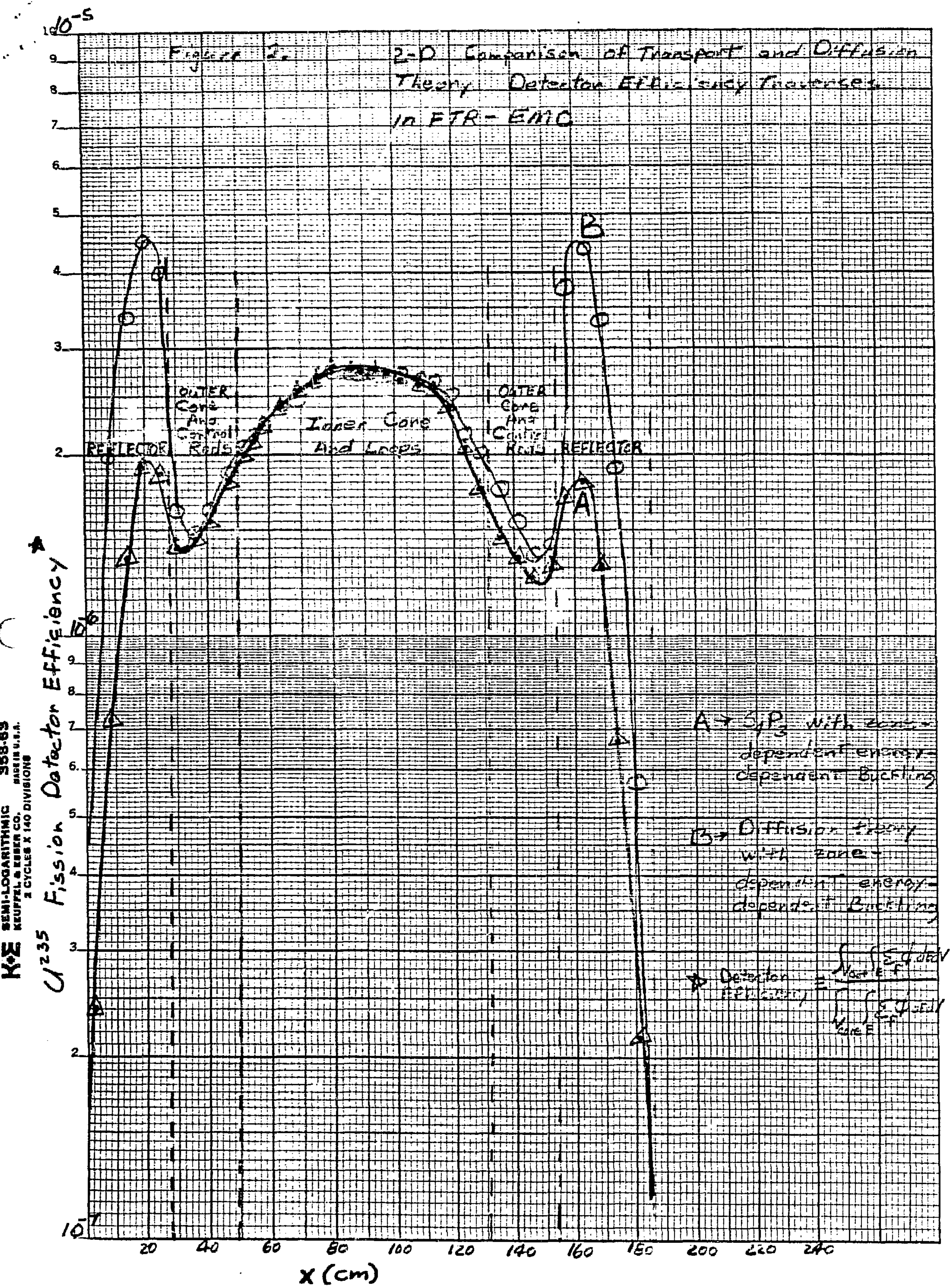

Figure 2.
2-D Comparison of Transport and Diffusion Theory Detector Efficiency Traverses in FTR-EMC
REFLECTOR
OUTER Core And Control Rods
Inner Core And Loops
OUTER Core And Control Rods
REFLECTOR
A
B
A → S_4P_3 with zone-dependent energy-dependent Buckling
B → Diffusion theory with zone-dependent energy-dependent Buckling
☆ Detector Efficiency = $\frac{\int_{V_{det}}\int_E \Sigma_F \phi \, dE dV}{\int_{V_{core}}\int_E \Sigma_F \phi \, dE dV}$
U^{235} Fission Detector Efficiency ☆
X (cm)
10^{-5}
10^{-6}
10^{-7}
20
40
60
80
100
120
140
160
180
200
220
240
K+E SEMI-LOGARITHMIC 358-63
KEUFFEL & ESSER CO. MADE IN U.S.A.
2 CYCLES X 140 DIVISIONS